Chapter 4

Face validity of a Wii U video game for training basic laparoscopic skills

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Accepted for publication (*American Journal of Surgery*)

Abstract

Background: Although the positive effects of playing video games on basic laparoscopic skills have been studied for several years, no games are actually used in surgical training. This paper discusses the face validity of the first video game and custom-made hardware which takes advantage of these effects.

Methods: Participants were recruited at the Chirurgendagen 2013 and the SAGES 2014 annual meeting. In total, 72 laparoscopic surgeons completed a demo of the game and filled in a questionnaire.

Results: On a 1-to-10 scale, the mean score for hardware realism was 7.2 and the mean score for usefulness as a training tool was 8.4. Participants didn't mind the fact that the workspace doesn't look like an abdominal cavity, but do have some trouble with the absence of tactile feedback.

Conclusion: We obtained face validity for both the hardware and the usefulness of Underground, a video game made for training basic laparoscopic skills.

Introduction

In the last twenty years, laparoscopy has become a standard part of surgical traineeship. Therefore, surgeons in training are required to learn and refine cognitive and psychomotor skills [1]. In most universities in the Netherlands, the basics of laparoscopy are taught through a training program such as the extensively validated FLS Program of the SAGES [2]. Besides these courses, trainees have access to Virtual Reality (VR) simulators, which are in most cases used voluntarily. VR simulators are becoming more important, since other methods, such as traditional box trainers or animal models, require human monitoring. This makes traditional methods subjective, expensive, and time consuming [3]. Not only can VR simulators be used to train basic laparoscopic skills, but they're also able to teach properties such as anatomy and procedural skills and knowledge.

Although most VR simulators have been validated to a certain extent [4,5], it is our experience that surgical trainees do not use them as they're supposed to. After the basic laparoscopy course most trainees skip the VR simulators and start their learning curve on actual patients. This way, none of the purported benefits of these simulators, such as training basic laparoscopic skills, anatomy, and procedural knowledge, can come to fruition.

There is increasing research on the effects of playing game on basic laparoscopic skills. Not only is there a correlation between video game experience and basic laparoscopic skills as tested on a simulator [6,7], but several experiments showed that video games can be used to improve basic laparoscopic skills on both the long [8,9] and short term [10,11]. Although these positive effects have been studied for more than ten years [12], no actual video game has been developed or used for surgical training.

Cutting Edge, a collaboration between the University Medical Center of Groningen (UMCG), the Leeuwarden Institute of Minimally Invasive Surgery (LIMIS) and Grendel Games, developed a video game, called Underground, and custom-made hardware to take advantage of the positive effects of playing video games of laparoscopic basic skills and to stimulate and intensify voluntary training in young surgeons [13]. In this video, which has been developed for Wii U console (Nintendo Co., Ltd., Kyoto, Japan), players use two Wii Remote controllers in custom-made laparoscopic tool shells to play a game that is based on movements made during laparoscopic surgery. In contrast to simulators, the game does not contain actual medical

content, but comprises of a story-driven mode, based on a fictional world where the player has to help small robots to escape from a deep mine. To aid the robots in their escape, the player controls two large robotic arms and demolishes and rebuilds the environment of the mine. The concept of a mine was chosen because laparoscopic surgeons also work in a primarily dark area and have to "break" things (adhesiolysis, ligation of mesentery, resections) before they can start to "rebuild" (anastomoses, hernia repairs). In the process, the development of a traditional simulator was knowingly avoided and thus does it only serve the purpose of training basic laparoscopic skills (eye hand coordination, depth perception, inverse movements and bimanual operation), and is not aimed at teaching anatomy or procedural skills or knowledge.

Figure 1: a screenshot of the game and a 3D render of the hardware that was used

Goals and hypothesis

Without convincing evidence, Underground would just be an ordinary video game. So before one can start using it as a tool for training, it has to be validated according to international standards [4,5,14], just as normal laparoscopic simulators. Previous research on the test validity of Underground showed solid construct and concurrent validity [15]. This paper is solely aimed at the face validity of the game. It is our hypothesis that laparoscopic surgeons, both experts and novices, will rate the hardware (realism, ergonomics, and movement) and the usability at

an acceptable level and have no problem with the fact that the software does not simulate an actual abdomen.

Methods

Participants

Participants were actively recruited at the Chirurgendagen 2013, the annual congress of the Netherlands Society of Surgery, and the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) annual meeting of 2014 in Salt Lake City. In total, 77 persons completed a demo of the Underground game and filled in the face validity questionnaire. Five persons were excluded because they had no experience with laparoscopy at all. The average age was 38.2 year and 91.7% of the participants were male. Surgeons, who had performed more than 50 laparoscopic interventions in the past five years (n=59), were considered experts.

Apparatus and tasks

The complete game set consists of a TV or a beamer, a Nintendo Wii U game console, two Nintendo Wii Remote controllers in custom-made laparoscopic tool shells, software, four infra-red (IR) Light Emitting Diodes (LEDs) placed on a base plate, and two small oarlocks on poles to resemble trocar sites (figure 1). The Wii Remotes use their built-in IR camera to see the IR LEDs on the bottom of the base plate. This way, their position can be determined and linked to the tools shown on the screen. The handles trigger the joysticks mechanically so that the graspers on screen can be opened in a natural way. A button on the back of the joystick is used to activate other tools, such as a driller or a welder. Although the game was still in development during this study, participants were able to play the final version of several levels of the game using the final version of the hardware. Participants were observed and instructed while playing the first, introductory two levels of the game, in which new tools and gameplay elements are introduced. The voluntary gameplay ranged from five to fifteen minutes.

Assessment

After completing the demo, participants filled in the face validity questionnaire. Since there is no standard questionnaire for face validity research, we composed a questionnaire based on other validation studies of laparoscopic simulators [3,16,17]. Besides closed questions on the importance of simulation in general and Underground as a training tool compared other simulators, 1 to 10 visual analogue scale (VAS) scores (1 = lowest score, 10 = highest score)

with questions on the authenticity of the controls, possible usefulness in training, and the lack of haptics and real anatomy were used to assess the opinion of the participants. A score of 6.0 or higher was considered as a sufficient score.

Evaluation

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) for Mac, version 19 (IBM, Armonk, NY, United States of America). Because not all data were normally distributed, the median scores of the questions (on a scale from 1 to 10) and their interquartile ranges were calculated. Answers to the questions and the statements were depicted using descriptive statistics.

Results

A summary of the responses to the questions in the face validity questionnaire can be found in table 1. On average, realism of the hardware scores a 7.2 out of 10. The usefulness of Underground as a serious tool for training was given a 8.4 out of 10. The answers to the closed questions can be found in table 2.

Table 1: Answers to the face validity questionnaire

Questions	**Score: median (inter-quartile range)**		
Underground hardware	*Novices (n=13)*	*Experts (n=59)*	*Total (n=72)*
How realistic do the instruments…			
… look in comparison to real instruments?	7.0 (2.5)	7.0 (2.0)	7.0 (2.0)
… move in the real world?	6.5 (2.5)	7.0 (2.5)	7.0 (2.5)
… work in the real world?	7.0 (2.0)	7.0 (1.5)	7.0 (1.9)
… move in the game world?	7.0 (3.0)	7.0 (2.0)	7.0 (2.5)
… work in the game world?	7.0 (2.0)	7.5 (1.5)	7.5 (1.5)
… are the ergonomics of the instruments?	7.5 (1.3)	7.5 (2.0)	7.5 (1.5)
Underground as a training tool			
How useful is Underground for training …			
… eye hand coordination?	8.5 (1.0)	8.5 (1.5)	8.5 (1.5)
… depth perception?	8.5 (1.5)	8.0 (1.5)	8.5 (1.4)
… inverse movements?	8.5 (0.8)	8.0 (1.5)	8.0 (1.0)
… bimanual operation?	8.5 (1.0)	8.5 (1.5)	8.5 (1.0)
… in general?	8.0 (2.0)	8.5 (1.5)	8.5 (1.5)
Possible Underground disadvantages			
How troublesome is the lack of tactile feedback? (1 = very troublesome, 10 = not troublesome at all)	5.5 (4.0)	6.0 (4.5)	6.0 (4.0)
How important is it that the workspace looks like an abdominal cavity? (1 = very important, 10 = not important at all)	8.0 (3.5)	8.0 (2.5)	8.0 (2.5)

Table 2 Answers to the face validity questionnaire

Statements	*Novices (n=13)*	*Experts (n=59)*	*Total (n=72)*
It is necessary that residents follow a basic laparoscopy course before they can operate on actual patients.	Yes: 92.3% No: 7.7% No opinion: 0%	Yes: 88.1% No: 10.2% No opinion: 1.7%	Yes: 88.9% No: 9.7% No opinion: 1.4%
It is important that residents train in a virtual reality setting (like the LapMentor, Simendo or Xitact).	Yes: 76.9% No: 23.1% No opinion: 0%	Yes: 84.7% No: 10.2% No opinion: 5.1%	Yes: 83.3% No: 8.3% No opinion: 8.3%
It is important that residents maintain their skills in a virtual reality setting using a virtual reality simulator.	Yes: 61.5% No: 7.7% No opinion: 30.8%	Yes: 76.3% No: 13.6% No opinion: 10.2%	Yes: 73.6% No: 12.5% No opinion: 13.9%
It is important that residents train in a virtual reality setting using a game (like the Underground).	Yes: 69.2% No: 7.7% No opinion: 23.1%	Yes: 69.5% No: 13.6% No opinion: 16.9%	Yes: 69.4% No: 12.5% No opinion: 18.1%
It is important that residents maintain their skills using a game (like Underground).	Yes: 46.2% No: 7.7% No opinion: 46.2%	Yes: 54.2% No: 25.4% No opinion: 20.3%	Yes: 52.8% No: 22.2% No opinion: 25.0%
Underground is a useful tool to measure laparoscopic skills.	Yes: 84.6% No: 7.7% No opinion: 7.7%	Yes: 76.3% No: 13.6% No opinion: 10.2%	Yes: 77.8% No: 12.5% No opinion: 9.7%
Underground is a useful tool for learning basic laparoscopic skills.	Yes: 100% No: 0% No opinion: 0%	Yes: 91.5% No: 3.4% No opinion: 5.1%	Yes: 93.1% No: 2.8% No opinion: 4.2%
Underground is potentially a cost-effective training tool to learning basic laparoscopic skills.	Yes: 61.5% No: 38.5% No opinion: 0%	Yes: 79.7% No: 3.4% No opinion: 16.9%	Yes: 76.4% No: 2.8% No opinion: 20.8%

Discussion

The results show that expert and novice laparoscopic surgeons both value the Underground video game at an acceptable level. Both the hardware and the transfer of movements to the video game world are deemed realistic compared to normal laparoscopy. The game also gets high scores when looking at its usefulness for training all basic laparoscopic skills that it is supposed to train; eye hand coordination, depth perception, inverse movements and bimanual operation. Although face validity is a very subjective measurement [14], we are satisfied with the aforementioned scores on hardware and usefulness and assume that the positive opinion of our participants can be generalised to the general surgical population.

Participants don't mind the fact that the workspace does not look like an actual abdominal cavity, but seem to have some trouble with the absence of tactile feedback in the game. It is possible to add some haptics to the game, because the Wii Remote does have a vibrating motor inside. However, it can only vibrate at one frequency, which will let the construction

vibrate in such a manner that the on-screen tools get disrupted. Due to this technical limitation, tactile feedback was scrapped in an early stage of development. The lack of tactile (or haptic) feedback is a common point of criticism for the majority of the laparoscopic simulators. However, the ones that do have tactile feedback, such as the LapMentor II (Simbionix, Cleveland, OH, United States of America), do not benefit from it [18,19]. In an experimental setting, haptics have proven useful in advanced tasks, resulting in faster completion, but did not demonstrate an appreciable performance improvement in basic laparoscopic tasks [20].

Limitations of the study

Face validity is a subjective form of validation [14]. For testing laparoscopic simulators, there is no standard questionnaire and no consensus on how many participants should be included in a study. We based our questionnaire on existing validation research on traditional simulators.

Another limitation of the study is the fact that the participants have not played the full and final version of the game. Since video games generally take much more time than a traditional simulator, testing a full version of the game would be too labor-intensive. However, the levels that were presented to the participants are representative for the rest of the game.

Finally, it should be mentioned that face validity is just a small part of supporting the test validity, which also consists of content, concurrent, and construct validity. The latter two have already been tested and published separately [15].

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